CHROMITE DEPOSITS OF CALAVERAS AND AMADOR COUNTIES, CALIFORNIA*

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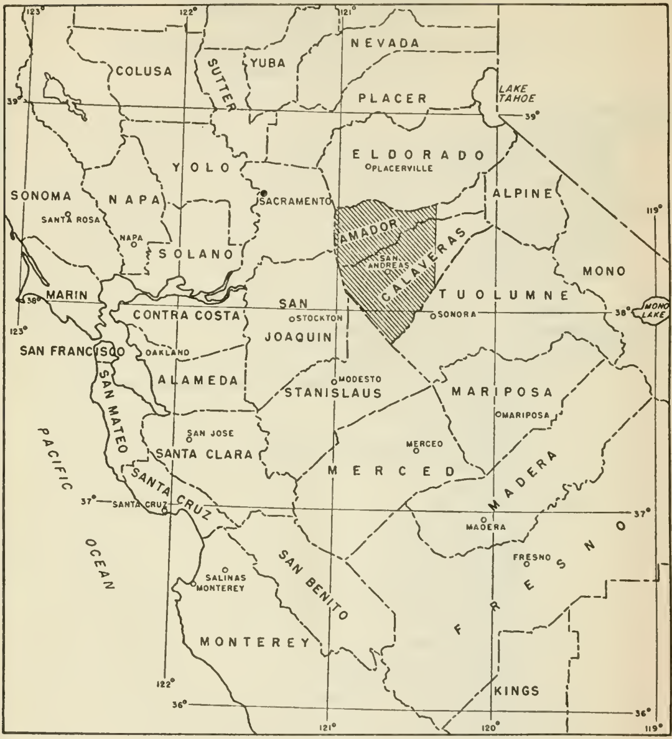

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ABSTRACT

The chromite deposits of Calaveras and Amador Counties have yielded over 7,000 long tons of chromite, all but a few hundred tons of which was lump ore. During World War II only 427 long tons was shipped, all of it from Calaveras County.

The report outlines the general geology of the counties and of the chromite deposits. Individual chromite mines and prospects are described, and a complete alphabetical list of them is included. The descriptions of mines and prospects are based on published and unpublished information gathered largely during the war years of 1917-18 and 1942-45.

INTRODUCTION

The chromite deposits of Calaveras and Amador Counties have yielded over 7,000 long tons of chromite, mostly lump ore, which has been mined intermitently since about 1890. With greatly increased chromite prices a few areas in the counties may still offer some inducement to the prospector.

Location, Topography, and Communications

Calaveras and Amador Counties cover an area of 1,622 square miles along the west slope of the central part of the Sierra Nevada between the Stanislaus and North Fork of the Stanislaus Rivers on the south, and the Cosumnes River on the north. The western parts of the counties where the chromite deposits occur are hilly, but not particularly rugged, except where cut by the canyons of the Stanislaus, Mokelumne, and Cosumnes Rivers. The eastern parts of the counties near the crest of the Sierra Nevada are much rougher and the relief is greater; some of the peaks rise to elevations of nearly 9,500 feet. Most of the population is concentrated in the western parts of the counties, and all the larger towns are along the Mother Lode. A network of paved and graded dirt roads serves most of the counties; spur lines of the Southern Pacific Railroad reach Milton and Kentucky House in Calaveras County and Martel in Amador County. Both counties are covered by topographic maps.

History and Production

Chromite has been known to exist in Calaveras County since the fifties, but little if any chromite is known to have been mined before 1890.

Much of the ore produced prior to the first World War was used locally for furnace linings in copper smelters. During the period 1916-18 wartime demand and increased prices stimulated production, but with the end of the war mining ceased until revived on a small scale by World War II.

Production figures prior to 1942, when all ore was purchased by the Metals Reserve Company, are unreliable. Official federal records

Table 1. Shipments of chromite by mines from Calaveras and Amador Counties, California (in long tons)

Calaveras County

Property	Map number	Pre-1916			1916	1917	1918	1919-1940			1941	1942	1943	1944	Total
		Year	Tons	Total				Year	Tons	Total					
Calaveras County															
American Asbestos Co.	6						52								52
Bowie Estate	1											59	21	13	93
Clary & Langford	13					223	125								348
Fields & Stoker	24 26						212								212
Gillan	21						72								72
Liberty	2					67	215								282
Madrid	28				565	357	60						57		1,039
Mayflower	3				192	69	332				74				667
Peri	7					71									71
Stone	9						92								92
Valenti	29											10			10
Vogelgesang	17	1,907	31	31	185	13							9		238
Walker	12						71								71
Ward & Lyons	27					87	1,212								1,299
Others				61		237	74	1920 1939 1940	20 118 41	179	25				576
Totals—Calaveras County				92	942	1,124	2,517			179	99	69	87	13	5,122

Amador County

Property	Map number	Pre-1916			1916	1917	1918	1919-1940			1941	1942	1943	1944	Total
		Year	Tons	Total				Year	Tons	Total					
Amador County															
Allan (Johnson lease)					63										63
Carr & Mefford					94										94
Courtwright (Wood and Roach lease)					54	31	31								116
Kremmel and Froelich					357										357
Wait					71										71
One other							17								17
Totals—Amador County					639	31	48								718

indicate that 4,675 long tons of ore was produced through 1918, but Diller (19) states that perhaps an additional 1,000 tons was mined before 1912. This production is not included in table 1 which lists only those data from which the county totals were calculated in the Minerals Yearbooks. For a number of mines that yielded appreciable amounts of chromite records are unavailable and for others are incomplete. In the descriptions of individual properties production estimates by others, chiefly Taliafero, are included for those properties for which federal records are lacking or appear to be incomplete. Shipments of chromite since 1942 are acurately known and probably represent very closely the actual output. From 1939-44 about 427 long tons of ore was shipped; thus the total recorded production from Calaveras County is 5,122 long tons, but actual production is probably somewhere between 6,500 and 7,000 long tons.

So far as is known the only chromite shipped from Amador County was mined during the first World War. This fact is rather surprising, as chromite had been known to occur at several easily accessible localities within the county for many years. Diller (19) states that the total production from the county to the end of 1918 was about 1,000 tons of chromite, of which only 718 long tons had been officially reported (see table 1). Production figures are incomplete, and a total of 300 tons was probably mined from a few mines for which there is no officially recorded production.

Field Work and Acknowledgments

This report is based partly on material collected intermittently from 1942-45 by F. W. Cater, Jr., D. H. Dow, and Fred Gros under the direction of Francis G. Wells, all of the federal Geological Survey, and partly on data contained in unpublished reports made in 1918 by N. L. Taliaferro to Dr. George D. Louderback, Chairman, Committee on Geology and Mineral Resources, State Council of Defense, and in Bulletin No. 76 of the California State Mining Bureau. In Calaveras County all properties recently active and all having a past record of substantial production were examined by geologists of the Geological Survey, but no attempt was made to visit all the chromite mines worked prior to World War II as most of them are caved and the time required to find and examine the old workings seemed incommensurate with the information to be gained. No chromite has been mined in Amador County since 1918, but most of the properties active in the first World War were examined by Cater.

The people of Calaveras and Amador Counties gave freely of their time and information in helping members of the Geological Survey during their investigations of the chromite deposits. Dr. N. L. Taliaferro of the University of California generously permitted use of part of his geologic map of the Copperopolis quadrangle prior to its publication. To his associates of the Survey who contributed important help in the preparation of this report, and for the information furnished by the geologic staff of the U. S. Corps of Engineers, the writer is grateful.

GEOLOGY

General Features

The oldest rocks in the two counties are mica schists, meta-cherts, crystalline limestone, and schistose volcanic rocks belonging to the Calaveras formation. Most of the rocks in this formation are believed to be of Carboniferous age, although rocks of Paleozoic age both older and younger than Carboniferous may also be present. Unconformably overlying the Calaveras formation are Middle and Upper Jurassic rocks comprising a series of sandstones and conglomerates, bedded tuffs, cherts, slates, and limestones, and thick layers of augite andesite and dacitic volcanic rocks which have been described by Taliaferro (43) and named the Amador group. Many of these rocks were formerly included in the Calaveras formation. The Mariposa slate of Upper Jurassic age overlies the Amador rocks very nearly if not quite conformably. At the close of the Jurassic, masses of peridotite, gabbro, diorite, and granodiorite, in the order named, intruded these older rocks at about the same time that the Sierra Nevada batholith was emplaced.

The pre-Tertiary rocks are compressed into a series of tight, almost isoclinal folds overturned to the west so that regional dips are easterly. Associated with the folds are a number of eastwardly dipping, high-angle reverse faults. The trend of the faults and the axes of the folds are roughly parallel and strike north-northwesterly. The gold-quartz veins of the Mother Lode are in one of the reverse-fault zones.

A profound unconformity separates the Tertiary rocks from the pre-Tertiary. The Tertiary rocks consist of clays and sandstones belonging to the Ione formation, later stream and marine-beach gravels, and andesitic and rhyolitic flows, tuffs, and agglomerate. These rocks have a gentle westward tilt but are otherwise undeformed. Large areas along the western margins of the counties are underlain by the Tertiary rocks, but farther east only isolated patches, chiefly of volcanic rocks, remain.

Ultramafic Rocks

Chromite, the only ore mineral of chromium, occurs only in rocks compounded of different amounts of olivine and pyroxene or their alteration products, the commonest of which is serpentine. All but the pure olivine rock, dunite, and the pure pyroxene rock, pyroxenite, are called peridotite. Most of the peridotite in Calaveras and Amador Counties is the variety called saxonite, composed of olivine and the orthorhombic pyroxene, enstatite; but associated with the saxonite are minor quantities of dunite and pyroxenite. All the ultramafic rocks in these counties are altered either in part or wholly to serpentine, but in this report rocks whose original composition is determinable are referred to by their respective names. The term ''slickentite'' has been applied to highly sheared serpentine and this usage is followed in this report.

The peridotite was intruded as sills into the pre-Tertiary sediments and volcanic rocks, very commonly along contacts between the major lithologic divisions of the Amador group or between the Adamor group and the Mariposa slate. These sills were probably injected while folding was still in progress and have been subjected in part to the same deformation as the host rock. More complete discussions of ultramafic rocks and their relations to chromite deposits and of the characteristics of chromite and chromite deposits are given in other chapters of this bulletin.

Local Features

Serpentine crops out in three belts trending north-northwest across the western end of Calaveras County, but only the eastern and western belts are continuous northward into and across Amador County (see plate

5). The belts are not continuous, but consist of a series of sill-like bodies that crop out as long, narrow strips, some of which are rather irregular.

The larger, more continuous western belt has yielded most of the chromite and is continuous southward with the west belt in Tuolumne County. Turner (94) mapped most of the serpentine in this belt as intrusive into so-called amphibolite schists. These rocks are now believed to be part of the Amador group, hence all of the serpentine in the western belt is probably confined to Jurassic rocks. Southward from a point east of Valley Springs in Calaveras County the belt splits into two separate branches which diverge southward to Calaveras River where they become parallel and about 2 miles apart. The western branch ends at Copperopolis. The structure suggests a closely compressed plunging fold, probably a syncline.

Although chromite deposits may occur anywhere within the serpentine masses, those in the western belt in Calaveras County appear to be localized most commonly along the margins of the masses, and more especially along the east margin of the east branch. If the east branch of the west belt is the east limb of a sill in a syncline, as seems probable, it would suggest a tendency for chromite to accumulate at the base of the sill. Most of the chromite is confined to the larger serpentine masses, and the deposits occur most commonly in clusters. Considerable areas of serpentine in the area east of Valley Springs and Campo Seco are concealed beneath late Tertiary deposits of clay, sand and gravel, and andesitic lava flows.

The middle belt of serpentine consists of a small mass in the vicinity of Carson Hill and a group of masses near San Andreas aligned with the eastern serpentine belt of Tuolumne County. Most of these masses have been intruded along the contacts between the Mariposa slate and the Amador group or along contacts between various formations of the Amador group. None of these serpentine masses has yielded any chromite, although the area is relatively free of brush and not difficult to prospect.

The eastern belt of serpentine is made up of smaller, more widely spaced masses of serpentine, which seem but vaguely related to the east serpentine belt of Tuolumne County. From a point 4 or 5 miles north of Angels Camp the belt trends almost due north across Calaveras County into Amador County. Although the individual masses are intruded along the beds of the Calaveras formation, the belt as a whole apparently does not follow the same horizon in the formation. Much of the serpentine in this belt is more highly altered than the ultramafic rocks in the western belt, and in places has been converted either in part or wholly into talc. The belt also contains one mass of pyroxenite.

Chromite Deposits

Most of the chromite deposits of Calaveras and Amador Counties occur as pods or irregular lenses of so-called massive chromite, or as lenses of low-grade ore that consist of alternating thin layers and clots of nearly pure chromite and nearly barren dunite. Only a few small deposits of disseminated ore have been discovered. Most of the dunite masses enclosing the ore bodies are small and many consist of little more than thin enveloping shells. Contacts between ore bodies and the enclosing serpentine are generally sheared and where shearing is intense the original rock is unrecognizable. In some localities deposits occur intermittently in zones several hundred feet long, elongated parallel to the major axis of the serpentine mass. In many deposits small amounts of secondary chromium minerals, mostly uvarovite and kammererite, have been formed. As a rule these minerals are more abundant in Calaveras County than in Amador County. Uvarovite and kammererite commonly fill small fractures and fissures in the ore and are most abundant in deposits cut by dikes of diorite, or of rodingite, a hard, fine-grained, light-colored rock composed of diopside, grossularite, zoisite, and prehnite.

Tenor of Ores

Chromite from Calaveras and Amador Counties varies widely in composition, but most of it is low in chromic oxide and high in iron. No complete analyses have been made of any of the ores from these counties, and assays of ore bought by the Metals Reserve Company are mostly of mixed lots from several different deposits.

Reserves

Many of the mines are worked out and only a few have any appreciable reserves. In the known deposits a few hundred tons of milling ore are available, and perhaps a somewhat smaller amount of shipping-grade ore could be mined under the stimulus of greatly increased prices. Any sizable production in the future must depend largely on new discoveries. The French Creek area in Calaveras County probably offers the best opportunities to those who seek new deposits.

DESCRIPTION OF CHROMITE DEPOSITS

The chromite deposits of Calaveras and Amador Counties fall into two groups; the west group includes those deposits located in the western serpentine belt and the east group those located in the eastern belt of serpentine. In each group clusters of deposits confined to a relatively restricted area within a single serpentine mass or assemblage of adjacent masses are treated as units within the larger group and are called areas. Some of the larger serpentine masses may contain more than one area.

West Group

Most of the chromite produced from Calaveras County and very nearly all the ore from Amador County have come from the west group of deposits. The group contains several areas which from south to north are: French Creek, Black Creek, Valley Springs, and Pardee in Calaveras County, and Mountain Springs and Plymouth in Amador County.

French Creek Area

The French Creek area lies about 5 miles southeast of Copperopolis on the southern end of the ridge known as the Bear Mountains.

The district drains partly into French Creek and Bean Gulch and partly direct into the Stanislaus River. The part of the area on the north slope of the Stanislaus River canyon is very steep and rugged, but back from the canyon the topography is less rough. The area has a total relief of about 600 feet. All the deposits in this area are in the north end of the large serpentine mass that continues southward across the Stanislaus River into Tuolumne County and makes up nearly all the west belt of serpentine in that county. The structure of the serpentine mass in this district and the adjoining Peoria Flat district south of the river in Tuolumne County is complex. Much gabbro is associated with the serpentine along the eastern parts of the mass, and the serpentine and gabbro are interlayered with lenticular masses of altered andesite and tuff. Two small irregular masses of grandodiorite cut the serpentine near the eastern contact.

A total of about 2,000 tons of ore, much of it containing over 45 percent chromic oxide, has been mined and shipped from the various deposits in the district. Most of this ore was produced either prior to or during the first World War, but sporadically from 1941-44 some of the deposits were reopened, a minor amount of exploration and mining was done, and 167 long tons of ore was shipped. Much chromite float is scattered over the area, and probably intensive search would uncover other deposits, but almost impenetrable brush hinders prospecting.

*American Asbestos and Manufacturing Company Mine (6)**. The American Asbestos and Manufacturing Company's mine is in the NW¼ NE¼ sec. 16, T. 1 N., R. 13 E., at an elevation of 1,050 feet, near the crest of a spur ridge not far from the confluence of French Creek and Rodgers Creek. Ore was mined from two shafts about 15 feet apart and 25 feet deep. The deposit consisted of a number of small, irregular, northwesterly trending pods of chromite ore of highly varied grade and texture. The various pods were made up of clots, bands, and irregular streamers of disseminated ore of all grades, massive chromite, and a small amount of nodular ore. The matrix of disseminated ore and the enclosing wallrock is sheared, gray, serpentinized dunite, and the predominant country rock is serpentinized saxonite. Numerous small veinlets of opal cut the serpentine and the ore. Contacts between the ore and wallrock are sheared in most places but some of the ore grades into barren dunite. The deposit has yielded 52 tons of ore; about 1 ton remains on the dump, and reserves are probably small.

Liberty Mine (2). The Liberty mine, also known as the McFall, is on a northeast slope about 30 feet above the bottom of Bean Gulch in the SE¼NW¼ sec. 9, T. 1 N., R. 13 E. The mine is about 7½ miles from Copperopolis—2 miles by paved highway, and 5½ miles by unimproved dirt road. During the first World War the property was owned and operated by the California Chrome Company, and since then has been idle. Present visible workings consist of a pit 15 to 20 feet deep, 25 feet long, and from 4 to 10 feet wide, and, about 80 feet northwest of the pit, an inclined shaft that is open to a depth of about 40 feet.

Taliaferro states that an inclined shaft was sunk to a depth of 75 feet in the pit, and that a drift was driven N. 70° W. from the foot of the shaft.

The deposit consisted of a number of small pods of massive and nearly massive chromite striking northwest and dipping northeast. The enclosing serpentine is highly sheared and contains considerable amounts of slip-fiber asbestos. Ore from the dump is brecciated, has a chocolate color, and a dull, earthy luster. Individual grains of unsheared chromite range from 0.5 to 2 millimeters in diameter. Small amounts of disseminated ore are present on the dump, but no ore remains in the workings now accessible. Thin smears of uvarovite occur on slickensided surfaces of chromite. On the opposite side of the gulch, 350 feet south of these workings, a small amount of low-grade ore crops out. No work has been done on this outcrop.

A total of 282 long tons of chromite containing 47 or 48 percent chromic oxide was shipped from the mine through 1918, but reserves, if any, are probably small.

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* Numbers refer to map, plate 5.

Mayflower Chrome Mine (3) (Burnham and Wilson Mine). The Mayflower mine is about 1,300 feet northwest of the Liberty mine a short distance southwest of Bean Gulch near the center of the NW¼ sec. 9, T. 1 N., R. 13 E. The mine is 7½ miles by road from Copperopolis. It was located and operated by W. A. Burnham and F. A. Wilson during the first World War. In 1941 the mine was reopened by C. A. Gillis and 74 tons of ore was shipped; Hunter did a small amount of exploration work and bulldozed a trail to the mine in 1942, but no ore was mined.

Workings consist of a small shaft 15 feet deep; an open-cut 45 feet long, 3 to 4 feet wide, and open to a depth of 40 feet; and a caved tunnel about 100 feet long that apparently connected with the bottom of the open-cut. The open-cut trends N. 30° W. and is vertical parallel to the chromite lenses mined from it.

The lenses were 1 to 4 feet thick and parts of some of them remain in the faces at both ends of the cut. Most of the ore is black, massive, medium-grained chromite having a submetallic luster, but small amounts of medium-grade disseminated ore are present. Considerable talc and kammererite occur with the chromite. The enclosing serpentine is highly sheared, especially near the ore zone, and the contacts of serpentine and chromite are slickensided. About 150 feet east of the ore zone the serpentine is in contact with older slates.

The mine has a recorded production of 667 long tons of chromite containing about 48 percent of chromic oxide; of this total, 74 tons was mined by Gillis in 1941. Reserves are probably limited to a few tons.

Dean Mine (4). The Dean mine is 1,100 feet northwest of the Mayflower mine about halfway up the northwest slope from the bottom of Bean Gulch in the NW¼NW¼ sec. 9, T. 1 N., R. 13 E. The mine is nearly 8 miles by road and trail from Copperopolis. During the first World War the mine was owned by Mills Mitchell and leased and operated by Steve Dean. No work has been done on the property since that time. Workings consist of three small open-cuts and a drift farther down the hill driven to intersect ore below the cuts.

The deposit consisted of a few small pods of massive chromite in gray serpentine, less than 200 feet from the east contact. The ore is black, nearly pure, medium-grained chromite containing minor amounts of kammererite. Numerous small veins of magnesite and opal cut the surrounding serpentine.

According to Taliaferro the mine produced about 10 tons of ore containing about 45 percent chromic oxide.

Holbrook and McGuire Group (5).—The Holbrook and McGuire group comprises about seven claims located in French Creek and along the crest of the ridge between French Creek and Bean Gulch. The workings are all in the NE¼ sec. 8 and the NW¼ sec. 9, T. 1 N., R. 13 E. Holbrook and McGuire owned and operated the property during the first World War; later the land was acquired by J. H. Bowie, and in 1942 Charles Hunter leased the mines from the Bowie Estate and mined a small amount of ore. Allan Dunbar then leased the property and did some additional work, but it is probable some of the ore he produced came from the nearby deposits described under the Bowie Estate.

Inasmuch as the various deposits on the property have markedly dissimilar characteristics they are described separately.

The low-grade deposit is near the crest of the ridge between French Creek and Bean Gulch in the SW¼NW¼ sec. 9. The ore was mined from a glory hole 40 feet long, 20 feet wide, and 20 feet deep; on each end of the glory hole are open-cuts, one of which just southeast of the glory hole is 50 feet long. The total strike length of the workings is nearly 200 feet. The tunnel, which taps the glory hole, is about 125 feet long and runs N. 35° E. into the hill.

The deposit consists of a zone of vertical lenses trending N. 45° W. Individual lenses may be as much as 20 feet long and 6 feet wide, but most of them are smaller. There is a slight tendency toward en echelon arrangement in which some of the lenses overlap. Both the matrix of the ore and the enclosing wallrock are highly sheared, talcose serpentine, and considerable brecciation is apparent in the ore. Most of the ore consists of small clots, lenses, and streaks of nearly pure chromite embedded in barren serpentine or in serpentine containing various amounts of disseminated chromite grains. Chromite makes up somewhat less than half the mass of the ore lenses, and ore that was milled is said to have contained about 20 percent of chromic oxide. Some of the streaks of ore were of higher grade and a small tonnage of ore was cobbed out by hand.

In 1918 a small concentrating mill was built below the tunnel and the tailings pile in the gully below the site of the mill indicates that several hundred tons of ore was treated.

About 1,000 feet southwest of the low-grade workings, in the bottom of French Creek, is a shaft from which Taliaferro states several carloads of ore was mined in the early nineties for use by the Campo Seco smelter. About 15 tons was mined during the first World War, but any fragments of ore that may have been left have washed away. Ordinarily the shaft is full of water.

The main high-grade workings are on the crest of the ridge about 1,000 feet northwest of the low-grade deposit. Workings consist of a steep inclined shaft, and just below this shaft a small open-cut and a small shaft 15 feet deep. The main shaft was reopened by Allan Dunbar in 1942 but no ore was shipped. Taliaferro says this shaft was 95 feet deep and most of the ore produced came from here. The ore occurred as a series of pods 1 to 4 feet thick and as much as 10 feet long. The zone of ore pods strikes about N. 50° W., and small amounts of ore are still to be seen in the walls of the shaft and in the lower workings. Most of the ore is coarse-grained massive chromite, and there is a small amount of disseminated ore. The chromite is jet black and has a submetallic luster. A shell of highly sheared dunite encloses the ore bodies. Numerous small veinlets of magnesite cut both the ore and serpentine. Taliaferro says that the ore contained 46 to 47 percent of chromic oxide and carefully cleaned ore as much as 53 percent.

About 1,000 feet southwest of this high-grade deposit, in the bottom of a gully tributary to French Creek, pieces of nearly massive chromite are scattered around a small caved shaft, and nearly 800 feet southwest of this shaft a small amount of low-grade spotted ore has been taken from a pit 8 feet long, 6 feet wide, and 5 feet deep.

Taliaferro says the total production of the whole property to July 1918 was about 600 tons of chromite that contained from 40 to 48 percent of chromic oxide. An unknown amount, probably not more than 200 or 300 tons, of concentrates and high-grade ore was produced after this date. Records from which the chromite production figures for Calaveras County were compiled in the Minerals Yearbooks, however, fail to mention any production from this property. Although some ore remains in most of the workings, the reserves are difficult to estimate and appear to be small.

Bowie Estate (1).—A number of deposits in addition to the old Holbrook and McGuire holdings are scattered about the Bowie Estate property, and some of them were described by Taliaferro. All of these deposits lie either in sec. 9 or 16, T. 1 N., R. 13 E.

About 600 feet northwest of the old American Asbestos Company's shaft in the NW¼NE¼ sec. 16, T. 1 N., R. 13 E. are 2 shafts a few feet apart now open to a depth of about 10 feet. It is doubtful that they were ever much deeper. Apparently no work has been done in them since 1918. The deposit consists of an irregular lens of chromite ore contained in a small lens of sheared, gray dunite, which lies in slightly sheared, serpentinized saxonite. The ore body is vertical, trends about N. 30° W., and consists of very irregular bands, stringers, and clots of medium-grade disseminated ore, and small, irregular masses of almost pure chromite. Only a small amount of ore remains on the dump and in the sides of the shafts. Taliaferro describes a lens of ore up to 5 feet in width as exposed in the bottom of the workings for a distance of 10 feet, and this lens may still remain, for the workings were idle when Taliaferro visited them in July 1918. About 90 long tons of ore containing 34.2 to 42 percent chromic oxide are said to have been produced from the deposit.

About 750 feet northeast of these shafts, Taliaferro says that about 10 tons of ore was mined in the southeast quarter of Section 9 from two small pits in a group of small lenses of low- to medium-grade ore in light-colored, leached serpentine. This deposit was not investigated by geologists from the Geological Survey.

A deposit in the SW¼ sec. 9, T. 1 N., R. 13 E., on the crest of the ridge between French Creek and Bean Gulch and about a quarter of a mile south of the road to Bean Gulch, was worked from a 10-foot shaft, a small pit, and an inclined open-cut 45 feet long, from 2 to 4 feet wide, and 15 feet deep. This deposit was worked in 1918, and Hunter mined about 15 long tons of ore from it in 1942. Although the total production is unknown, the size of the workings indicates that perhaps 100 tons of ore has been produced. The ore body is an irregular lens trending N. 30° W. and dipping from 25° to 45° NE. The ore consists of somewhat brecciated irregular bands and clots of high-grade disseminated and massive medium-grained chromite. Slickentite containing considerable talc and numerous small magnesite seams surrounds the deposit. Only small amounts of ore remain in the ends of the open-cut and reserves are probably negligible.

A few hundred feet to the southeast, very near the highest point on the ridge, a small amount of highly sheared ore has been mined from two small pits and a considerable area scraped bare by a bulldozer. The ore and the country rock are similar to those of the deposits just described except that a small amount of malachite occurs in some of the fractures. Reserves are negligible.

About two carloads of chromite was mined from a deposit discovered in 1942, half way up the west slope of the hill about 1,000 feet southwest of the two small pits just described. The deposit was worked to a depth of 30 feet over a strike length of 30 feet. The ore consists of brecciated massive and nearly massive medium-grained chromite containing numerous seams of uvarovite. Contacts of the ore and the enclosing highly sheared serpentine are sharp and slickensided. Little ore remains.

Some massive, medium-grained chromite was mined during the first World War from a small open-cut and shaft, now flooded, at the foot of the hill about 1,500 feet northwest of the Bowie house. A few fragments of high-grade ore are scattered around a small caved shaft just east of the house.

A few small open-cuts and an area scraped bare by a bulldozer are just north of the Bean Gulch road about a quarter of a mile southeast of the main low-grade workings of the Holbrook and McGuire mine. Some ore was mined from here during the first World War and in 1942 Hunter mined 15 long tons.

In addition to the above-described deposits a number of other small workings are said to be scattered through the almost impenetrable brush. Considerable float is scattered all over the ridge, and with intensive prospecting more deposits undoubtedly could be found. The total production of the property is probably not less than 400 long tons, though none is recorded in the Minerals Yearbooks before 1942. Reserves of ore in known deposits, however, are small.

Peri Mine (7).—According to California State Mining Bureau Bulletin No. 76 (Bradley, Walter W., 18), the Peri mine is in the SE¼ sec. 6, T. 1 N., R. 13 E. Local residents claim the deposit is about 1 mile northwest of Funk Mountain in the NW¼ sec. 32, T. 2 N., R. 13 E., and inasmuch as there is no serpentine in the SE¼ of sec. 6, sec. 32 seems the more probable location. The property has never been investigated by the Geological Survey. The mine was leased from Frank Peri by Frank Towers, Frank Reddick, and William Dixon and operated by them in 1916-17. The following description of the property is quoted from Bulletin No. 76.

> "Lenticular bodies of chrome ore strike east-west with a footwall of serpentine and hanging wall of schist and metamorphic sandstone.
>
> "The main workings consisted of an open cut 14′ deep and 40′ long in the west face of which ore was exposed 2′ wide and 4′ high. About 40′ east of this cut a 20′ shaft had been sunk with a windlass. This incline followed a lower grade ore body which pitched N. 80° and was exposed 2′ wide over the lower 5′ of the east side. About 40 tons of 30 percent ore were on the dump and it was said that 48 tons of ore had been shipped in 1916. Open cuts on top of the hill had yielded 20 tons of ore and only small seams were left exposed."

The total recorded production from the mine was 71 long tons. Mining ceased in 1917.

Black Creek Area

The chromite deposits of the Black Creek area are in a cluster of rather irregular masses of serpentine that crop out on the ridge in the area drained mostly by Black Creek. The ridges trend north-northwesterly parallel to the structure of the underlying rocks and have a relief of about 1,200 feet. The largest of the serpentine masses is about 3½ miles long and about three-quarters of a mile wide, and has been intruded by a mass of granodiorite. The other serpentine masses are uncomplicated by later large intrusions and are considerably smaller; the largest of them is only 1½ miles long and the smallest less than a quarter of a mile long and only a few hundred feet wide. Most of the chrome mines are no longer accessible by road. The total production of the district is about 2,000 tons, all mined either before or during the first World War, though some was sold later.

Stone Mine (9).—The Stone mine has also been known as the Coffer, Trask, and Stone lease, and as the Longton mine. In 1945 the property was owned by Charles J. Stone, but during the period of active mining in the first World War, C. E. Longton owned the land and Coffer, Trask, and Stone leased the mine. The workings are in the SE¼ sec. 23, and the SW¼ sec. 24, T. 2 N., R. 12 E., along the sides of a gulch tributary to Black Creek. The deposit was worked from five shafts, three of which were flooded when visited by Cater in 1945.

Taliaferro states that the main shaft is 40 feet deep and that two drifts were driven from the bottom of it along a lens of ore about 3 feet wide and striking N. 25° W. The country rock is sheared, talcose serpentine and specimens of ore from the dump are of massive, medium- to coarse-grained chromite.

A somewhat irregular shaft said to have been 35 feet deep is about 250 feet N. 20° W. of the main shaft. Scattered pieces of ore on the dump are similar to those found at the main shaft. A 15-foot shaft nearby is in a small lens of banded, disseminated ore about 40 feet west of the serpentine contact. This ore body strikes N. 55° E. and is traceable for about 15 feet. The banding dips vertically and lies parallel to the trend of the ore zone. Layers of high-grade disseminated chromite a quarter of an inch to 1 inch thick alternate with barren serpentine forming an ore containing an average of 60 percent chromite.

Probably very little, if any, chromite was mined from a 30-foot shaft about 500 feet S. 15° E. of the main shaft, for no ore was seen on the dump.

The fifth shaft, about 35 feet deep, lies across the gulch about 500 feet west of the main shaft. Ore from this shaft is very coarse-grained massive chromite without visible interstitial gangue.

All the ore bodies are near the east contact of the serpentine.

The mine has a recorded production of 92 long tons of ore, most of which came from the main shaft. Though some ore is said to remain in the bottom of the high-grade workings, reserves are probably small.

Davis Mine (10).—Taliaferro describes the Davis mine as part of the Coffer, Trask, and Stone leases, but the mining is said to have been done by W. A. Burnham. A Mr. Beecham bought the property after the first World War. The workings are in two groups. The south workings consist of three closely grouped open-cuts 15 to 20 feet long and up to 10 feet wide. They are just north of the Pacific Gas and Electric Company's power line about halfway up the west slope of the hill, on the opposite slope from the west shaft of the Stone mine. The north workings are a quarter of a mile northwest of the south workings, just west of a saddle on the crest of the ridge. These workings consist of an irregular open-cut and some caved, rather shallow underground workings leading from the open-cut. All the workings are in the SE¼ sec. 23, T. 2 N., R. 12 E.

The workings have slumped, and any ore bodies are concealed. The open-cuts on the south deposit trend about N. 30° W. and probably indicate the trend of the ore. All the workings are in sheared serpentine, but a few blocks of saxonite are recognizable. Fragments of medium-grained massive chromite are scattered about the various dumps.

About 225 long tons of ore is said to have been produced from the property, and the deposits are probably worked out.

Burnham Mine (11).—The Burnham mine is about half a mile northwest of the north workings on the Davis mine, in the NW¼ sec. 23, T. 2 N ,

R. 12 E., on land now owned by Mr. Beecham. In 1915 about 65 tons of chromite was mined by W. A. Burnham from a shaft said to have been 40 feet deep. This ore was stockpiled at the mine, and in 1927 the owners of the property sold the ore for $5 a ton. The mine was not visited.

Walker Mine (12).—The Walker mine is also known as the Chaparral and the Brushy Hill mine. F. G. Walker first worked the mine in 1917; in 1918 it was worked by C. A. Gillis, and in 1940 by B. W. Cresswell. The property, which consists of 3 open-cuts and 3 partly caved shafts, one 60 feet deep and the other two each about 40 feet deep, is near the center of the E½ sec. 15, T. 2 N., R. 12 E., near the head of a gulch tributary to Black Creek. Some of the workings were cleaned out by Mr. Cresswell but no additional shipping-grade ore was found and no high-grade ore shows in any of the workings.

The workings are in highly sheared serpentine very near the west contact of the serpentine with granodiorite. According to Taliaferro, most of the ore was mined from the 60-foot shaft, and two short drifts were driven, one to the northwest and one to the southeast, at a point 15 feet from the bottom. The maximum thickness of the massive ore was about 2 feet; a small amount of disseminated ore was also present. The second shaft is about 200 feet S. 45° E. of the main shaft, and the third, which yielded about 30 tons of ore, is about 2,000 feet S. 80° E. from the main workings.

The recorded production from the various workings is 71 long tons of chromite which averaged about 40 percent of chromic oxide but ran as high as 47 percent. Reserves are probably negligible.

Clary and Langford Mine (13).—The Clary and Langford mine, also known as the Porter and Spring, is in the NW¼ sec. 10, T. 2 N., R. 12 E., about 150 feet east of Copperopolis-Angels Camp road at a point about 0.6 of a mile north of the Milton road junction. The mine was first operated some years prior to the first World War and 100 tons of ore is said to have been used by a local copper smelter as furnace linings. In 1916-17 the mine was leased by H. Clary and George Langford who produced 223 long tons of chromite containing 45 to 46 percent of chromic oxide. J. E. Porter and J. H. Spring acquired the property in 1918, and produced an additional 125 long tons of ore; thus, the total recorded production is 348 long tons.

The main workings east of the road consist of a flooded open-cut, and two flooded shafts, each said to be 45 or 50 feet deep. The ore was in highly sheared serpentine. No ore can be seen in place but a few fragments of medium- to coarse-grained massive chromite containing minor quantities of kammererite are scattered about the dumps. Taliaferro states that about 60 tons of ore is said to have been mined from a lens over which the road passed. The road was shifted, the ore mined, and then the road was restored to its original position. A shaft and a few small cuts were reported by Taliaferro in a small detached mass of serpentine half a mile to the west. Reserves in all the workings are probably negligible.

Hinch Mine (14).—The Hinch mine is in a small mass of serpentine at the south end of a ridge a quarter of a mile north of Pooles Station in the SW¼ sec. 3, T. 2 N., R. 12 E. In 1905 about 15 tons of chromite was mined for furnace linings for a nearby copper smelter, and during the first World War the mine was leased by F. W. Dean and Fred Wilson from Mr. Hinch. Dean and Wilson are said to have produced about 300 tons of ore from 3 open-cuts and a shaft which are scattered over a distance of 150 feet along a northwesterly trending line.

The deposit consisted of a number of irregular, northwesterly trending pods and lenses of medium-grained, almost massive chromite. Most of the country rock is sheared, serpentinized saxonite, but very small amounts of serpentinized dunite are recognizable immediately adjacent to the spaces from which the chromite was removed. Contacts of the ore and serpentine were sheared and slickensided. No ore remains in place and only scattered fragments are found on the dump, some of which contain small amounts of kammererite. Though more ore may be found by deeper mining, reserves are probably small.

Other Deposits.—Some ore is reported to exist on the Bear Mountain Ranch (8) in a small serpentine lens in the SE¼ sec. 24, T. 2 N., R. 12 E. Henry Poch is reported to have produced some ore from three open-cuts in sec. 29, T. 3 N., R. 12 E., on the Matthew Ranch (15).

Valley Springs Area

The chromite deposits of the Valley Springs area are along an 8-mile section of a single serpentine mass which at its closest approach is about 2 miles east of Valley Springs. This mass has a total length of about 20 miles and it ranges in width from a few hundred feet to 1½ miles. Smooth, moderately steep ridges having a relief of about 500 feet dominate the topography. These ridges trend north-northwest parallel to the structure of the underlying rocks. All parts of the area are readily accessible, at least during the dry season, over a system of dirt and paved roads.

Vogelgesang Mine (17).—The Vogelgesang mine is on the floor of a valley about a quarter of a mile wide near the center of the SW¼ sec. 34, T. 4 N., R. 11 E., on land owned by G. D. Vogelgesang. The mine has been inactive since the first World War, when D. L. McAfee operated it. The mine is about 8 miles by road from Valley Springs, 5 miles of which is paved and 3 miles unimproved. Workings consist of several open-cuts, the largest being 55 feet long, 4 to 6 feet wide, and 30 feet deep.

The deposit consists of a group of pods and lenses of massive chromite traceable for 230 feet along a shear zone striking N. 35° W. and dipping 75° NE. This zone lies parallel to and 10 to 30 feet east of the western contact of the serpentine, which in this area is not over 1,000 feet wide. A few scattered pits continue along the same strike for an additional 300 feet, but very little chromite has been taken from any of them. Most of the country rock is slickentite but near the contact with the older metamorphic rocks much pyroxenite is found. A pegmatite dike composed of large crystals of plagioclase, pyroxene, and muscovite is intruded along the same shear from which the largest single lens of chromite was mined. The ore is massive, medium-grained chromite having a black color and a submetallic luster. The largest single lens was about 50 feet long, had a maximum thickness of 4 to 5 feet, and was mined to a depth of 30 feet.

About 229 long tons of ore containing 43 to 46 percent of chromic oxide was shipped from this property and about 15 tons was still stockpiled at the mine in 1943. In deposits of this type estimates of reserves are impossible, but probably more lenses could be found with deeper mining.

Ellingwood Mine (19).—The Ellingwood mine is in the NW¼ sec. 21, T. 4 N., R. 11 E., about a mile north of the Calaveras River on the west slope near the bottom of a small side canyon. About three miles of unimproved dirt road and 5 miles of paved highway connect the mine to Valley

Springs. The property was first worked in 1910 by the Penn Copper Company and the chromite was used at the Campo Seco smelter for furnace linings. During the first World War the property was owned by William Ellingwood and operated by D. L. McAfee, but later the City of Stockton acquired the property as part of the area surrounding the reservoir above Hogan Dam. During 1941 the mine was reopened and a small amount of ore was shipped.

Workings consist of two open-pits, two tunnels, and a winze. The larger pit is 85 feet long, 10 to 20 feet wide, and 15 feet deep. The winze and part of the tunnels are inaccessible.

The deposit is within 150 feet of the contact of the serpentine with metamorphosed old sediments and schists. Chromite occurs as a vertical lens striking N. 35° W. The size of the stopes indicates that the lens was 8 to 10 feet thick. Sheared serpentine probably derived from dunite forms the wallrock of the ore body but the predominant country rock is saxonite. Contacts of the ore and serpentine are sheared and slickensided, and some small blocks of chromite, perhaps sheared from the main ore body, are visible along and near the old stopes. The ore is massive, medium-grained chromite; some kammererite is present between grains and along fissures.

Two flooded shafts about 1,000 feet south-southeast of the above-described mine are in the bottom of the creek. According to Taliaferro a lens of ore from 6 inches to 2 feet thick was exposed in one of these shafts. Pieces of massive, medium-grained ore are scattered about the dump. This deposit is only 75 feet from the eastern contact of the serpentine.

The mine has produced a total of about 500 long tons of ore said to contain an average of 38 percent chromic oxide, but no mention of production is contained in official records. A few tons of ore are in sight, but the lower workings are inaccessible, and the reserves are unknown.

Ellingwood and Vogelsang Mine (18).—The Ellington and Vogelsang mine is about a mile north of the Vogelgesang mine and a little over half a mile south of the Calaveras River on an east slope near the base of a ridge in the SE¼ sec. 28, T. 4 N., R. 11 E. The property is owned by William Ellingwood and during the first World War was operated by Ellingwood and Vogelsang. Chromite was mined from an open-cut and a short drift. The open-cut is about 20 feet long, 12 feet wide at the face, and 8 feet deep in the deepest part; near the end of the open-cut a short drift doubles back nearly parallel to the cut. Sloughed debris obscures any chromite that may still be in place, and the shape and attitude of the ore body are unknown. The country rock is sheared saxonite, but in the immediate vicinity of the ore body the serpentine is so highly sheared the original composition of the rock is no longer recognizable. Pieces of ore on the dump are of medium-grained massive chromite having a submetallic luster; many of these pieces are slickensided. The deposit lies about 250 feet west of the east contact of serpentine with the older metamorphosed tuffs, lavas, and sediments. The production from this mine is unknown but is said to have been over 200 tons. The reserves appear to be small.

Other Deposits.—On the Maxwell claim (16) located in the SW¼ sec. 2, T. 3 N., R. 11 E., 33 tons of chromite containing 47 percent of chromic oxide was mined from a single pod in 1916. There is said to be some low-grade ore in the vicinity. From a quarter to half a mile northwest of the Ellingwood mine in the NE¼ sec. 20, T. 4 N., R. 11 E., Si Granadas (20) is said to have opened up a few small deposits, but no ore has been shipped.

Pardee Area

The Pardee area lies north of the Valley Springs area, in the same serpentine mass, and includes those deposits in the vicinity of the Pardee reservoir, between the Valley Springs-San Andreas highway and a point 1 mile north of the reservoir in Amador County. Except for the rugged part bordering the Mokelumne River the area is one of moderate relief and smooth, rolling hills. The old roads to the chromite deposits have grown up with brush and are no longer passable. Only one mine in the district has been operated since the first World War.

Gillam Mine (21).—The Gillam mine is 3 miles northeast of Valley Springs, just north of the crest of a small, rocky hill in the SE¼SW¼ sec. 5, T. 4 N., R. 11 E. About 5 miles of paved road and a quarter of a mile of trail connects the mine with the railroad at Valley Springs. The following description is from Taliaferro's unpublished report:

> "The development work consists of a long, narrow open cut 100 feet long and 22 feet deep in the deepest place. This runs to the S. 30° E., into the rather gently sloping hillside. Forty feet from the entrance and in the floor of the cut is a shaft 22 feet deep. About 20 to 25 tons of ore are in sight unmined.
>
> "The ore occurs in small irregular bodies and appears to be of shipping grade, carrying 31 percent to 35 percent Cr_2O_3. The ore trends roughly N. 30° W. Both ore and serpentine are cut by numerous slips.
>
> "The serpentine in which the ore is enclosed is hard and dense and dark gray to greenish gray in color. This is partially, and in places, wholly opalized, being converted into a dense dark brownish red opal rock. In places the structure of the serpentine is retained. Near the surface the opalized serpentine has been weathered and altered and rounded cores of partially or wholly opalized serpentine stand out sharply from areas of soft porous yellowish or whitish altered material. In the shaft and 15 to 20 feet below the surface the opalized serpentine is hard and massive and has suffered little of this type of weathering."

The property is owned by Jefferson Gillam and during the first World War was leased and operated by A. C. Kerley and Walton Van Winkle, but since 1918 the mine has been idle. About 72 long tons of ore was produced, and the deposit is said to be mined out.

Neugebauer Mine (23).—The Neugebauer mine is in the SE¼ sec. 31, T. 5 N., R. 11 E., about three-quarters of a mile north of the Valley Springs-Mokelumne Hill highway just west of a fork of Cosgrove Creek. The boundary fence of the Pardee watershed protection area runs directly over some of the workings. Part of the deposit is on land now owned by the City of Oakland and the rest is on land owned by Charles Neugebauer. The deposit was worked from three small pits, a 12-foot shaft, and a number of small trenches scattered over an area about 200 feet long. The deposit consists of a number of small irregular lenses and pods dipping eastward about 60° and trending about N. 25° W., parallel to the contact of the serpentine and older metamorphic rocks exposed about 200 feet east of the workings. The country rock is schistose serpentinized saxonite containing thin enstatite-rich layers in places. Only small amounts of dunite are recognizable along contacts of the ore, and most of the rock in the immediate vicinity of the ore bodies is highly sheared and cut by numerous veinlets of opal and chrysotile. The ore is considerably sheared and brecciated and consists of spotted or evenly disseminated chromite in which are embedded clots and irregular bands of massive chromite. Small amounts of kammererite are associated with the ore.

Although 15 to 20 tons of ore are piled about the various workings, none has ever been shipped. Only a little ore is visible in place about the workings.

Briggs Lease (24) (Fields and Stoker Mine).—The Briggs lease is about a quarter of a mile north-northwest of the Neugebauer mine and 250 feet west of the fence enclosing the property now owned by the City of Oakland near the center of sec. 31, T. 5 N., R. 11 E. Fields and Stoker located the claim during the first World War and A. L. Briggs leased the property from them. When operations ceased at the end of the war Briggs had mined nearly 125 tons of chromite. The deposit was worked from two shafts about 100 feet apart and a drift 40 feet long heading north-northwesterly from the bottom of the lower shaft, which is about 15 feet deep. The deposit consisted of a few irregular north-northwesterly trending pods and lenses of massive medium-grained chromite which dip steeply eastward. The trend of the ore bodies is parallel to the schistosity of the serpentine and to the contact, which lies about 200 feet east of the workings.

Slickentite containing a few fragments of saxonite is the most abundant country rock, and contacts between the ore and serpentine are sheared. A little chromite, some of which contains small amounts of kammererite, remains in the walls of the shafts, and according to Mr. Fields a lens of chromite 2½ feet thick was being worked at the time operations were shut down.

Fields and Stoker Mine (26).—The Fields and Stoker mine is about half a mile southeast of the Ward and Lyons mine on the west side of McAfee Gulch in the SE¼ sec. 24, T. 5 N., R. 10 E. The City of Oakland now owns the property. About 5 miles of paved road, 2½ miles of poor dirt road, and half a mile of trail connect the deposit with Valley Springs, the nearest shipping point. Workings consist of three small pits and an inclined shaft about 25 feet deep. The ore occurred as rather small lenses of coarse-grained massive chromite trending about N. 35° E. and dipping 70° NE. Contacts of the ore and the enclosing, somewhat sheared, serpentinized dunite are sharp and slickensided. Little ore remains in sight, but about 3 tons are stockpiled on the dump. The total production is unknown, though near the end of July 1918, at the time of Taliaferro's visit, 48 long tons of ore containing 42.48 percent of chromic oxide had been shipped and 45 tons were on the dump awaiting shipment. Reserves are probably small.

Ward and Lyons Mine (27).—The Ward and Lyons mine is about 250 feet above the Pardee Reservoir in the NW¼ sec. 24, T. 5 N., R. 10 E., on land now owned by the City of Oakland. During the first World War the property was owned by A. M. Lyons, Mrs. Grace Lyons, and R. M. Ward, and was operated under bond by A. C. Kerley and Walton Van Winkle.

In 1943 the face of the pit had caved in, and only a small exposure of chromite was visible, although a good deal of ore was said to have been left in the mine. Taliaferro states the open-cut in 1918 was 100 feet long, but in 1943 it was only about 70 feet long, 65 feet wide, and 30 feet deep. The ore was hoisted to the end of the road at the top of the hill on a tramway 400 feet long. About 50 tons of ore was mined from a pit about halfway up the tramway.

Taliaferro described the ore body as a large, somewhat irregular lens trending north and dipping eastward at 30° to 40°. The lens had a maximum thickness of 14 feet and an exposed length of 40 or 50 feet. Saxonite is the predominant country rock, but a relatively thin shell of sheared dunite encloses the ore. Numerous dikes now altered largely to chlorite cut the deposit; these dikes are probably responsible for the relatively large quantities of uvarovite and kammererite associated with the ore. The character of the ore is variable both in grade and texture; some was massive, coarse-grained chromite, but much of it contained interstitial serpentine, and the overall grade of the ore shipped was only 30 to 32 percent chromic oxide. Grains of chromite in specimens of massive ore from the dump are 3 to 4 millimeters in diameter, but in the medium-grade disseminated ore the grains are only about 0.25 of a millimeter in diameter.

The total recorded production is 1,299 long tons of chromite. Because of the present lack of exposures reserves cannot be estimated, but they may be considerable.

Fields Mine (28).—The Fields mine in Amador County is in the SW¼ sec. 10, T. 5 N., R. 10 E., on land now owned by the City of Oakland. Several hundred feet of trail, 1 mile of poor dirt road, and 8 miles of paved highway connect the mine with the railroad at Martel. Albert Fields located and operated the mine during the first World War, but the property has been idle since 1918. The ore was mined from a single steep inclined shaft which is now open to a depth of 15 feet. The deposit consisted originally of an irregular lens of ore from 1 to 3 feet wide and 30 feet long, striking N. 10° E. and dipping 65° SE. A number of small cross faults cut the lens, and contacts between the ore and the enclosing serpentinized dunite are sheared and slickensided. Sheared saxonite is the predominant country rock. The ore is medium-grained massive chromite containing considerable uvarovite. One ton of ore remains on the dump and a few small scattered pieces of ore are still in sight in the walls of the shaft. The production of the mine is unknown, but judging from the visible workings may have been as much as 50 tons.

Other Deposits.—About 6 tons of high-grade disseminated and massive chromite was mined in 1942 by Lew Coffer from a small detached serpentine lens in the SW¼ sec. 32, T. 5 N., R. 11 E. The property is owned by Mr. McNamara (25). The ore contained 43.02 percent of chromic oxide and was mixed with some ore from the Bowie Estate and shipped in 1943. About 1 ton of ore was mined in 1918 from a small pit 400 feet south of this deposit. J. D. Sartorius and Clifford McClellan (22) located a claim in 1918 on the Valley Springs-Mokelumne Hill road in the NE¼ sec. 6, T. 4 N., R. 11 E. The deposit consisted of a stringer of low-grade disseminated ore 4 inches wide.

Mountain Springs Area

The Mountain Springs area includes the deposits between a point half a mile north of Mountain Springs on the Ione-Jackson highway and a point 2½ miles south of the highway. The serpentine crops out in a north-northwesterly trending ridge that is about 300 feet high and has smooth, exceptionally brushy slopes. About 820 long tons of chromite has been shipped from this area. None of the mines is any longer directly accessible by road.

Ellis Property (29).—The deposits on the Ellis property are in the NW¼SW¼ sec. 2, T. 5 N., R. 10 E., on land belonging to J. M. Ellis. The deposits are accessible from Martel over 7 miles of paved road, 1½ miles of poor dirt road, and half a mile of brush. Workings consist of one small pit and a number of prospect trenches. Several small brecciated lenses and stringers of massive and disseminated chromite crop out along a zone several hundred feet long trending N. 30° W. parallel to the contact of the serpentine with older rocks which lies 300 feet to the east of the deposits. All the lenses are small, ranging from 1 to 3 feet in thickness and up to 25 feet in length. The lenses strike N. 30° W. and dip 30° NE., parallel to the schistosity of the serpentine. The ore bodies are surrounded by schistose and talcose serpentine, much of which is cut by intersecting fissures filled with chalcedonic quartz. Contacts of the ore and serpentine are sheared and quite irregular. About 10 tons of ore is stacked at the pit, but none has ever been shipped. A sample of this ore assayed by V. R. Fitzsimmons contained 40.22 percent of chromic oxide. Reserves are probably less than 50 tons.

Courtwright Property (30) (Daggett Lease).—The Daggett lease on the Courtwright property is in the SE¼ sec. 3, T. 5 N., R. 10 E., on land owned by Lydia Courtwright. The workings consist of three tunnels with caved raises to the surface and two shafts along the southwest slope near the bottom of a gulley tributary to Stoney Creek. The tunnels are spaced at intervals of about 600 feet along a northwesterly trending line. When visited in 1943 all the workings were flooded and inaccessible. R. E. Daggett leased and began work on the property in 1916. According to Logan (Bradley, 18), an ore body 20 feet long and 6 feet wide striking north and dipping 65° E., was mined from the most northwesterly of the two shafts, and elsewhere an open-cut followed a stringer of chromite striking N. 35° W. and dipping 65° NE. This open-cut apparently is what now appears as a caved raise from the center tunnel. The host rock is serpentine, some of which is talcose, but some unsheared, serpentinized dunite was found on the dump. The ore, of which about 3 tons remains on the various dumps, consists of fine- to medium-grained massive chromite. About 60 tons of ore averaging about 40 percent chromic oxide and 4 percent silica was shipped from the property in 1916. Reserves are not known.

Carr and Mefford Mine (31) (Mooney Claim).—The Carr and Mefford mine is in the W½SE¼ sec. 34, T. 6 N., R. 10 E., just east of the crest of a north-northwesterly trending ridge. The property is owned by Devem Cenzi. During the first World War, J. E. Mefford owned the property, and Carr and Mefford operated the mine until 1918 when L. Mooney acquired the title to it, and Leam, Furey, and Ford leased the mine. Chromite was mined from four open-cuts, one of which is 65 feet long and from 1 to 3 feet wide, and some underground workings, now largely caved.

The ore consists of massive medium-grained chromite and disseminated grains of chromite in a matrix of serpentinized dunite. Stringers of ore up to 4 inches wide remain in the walls and ends of the open-cuts. These stringers and the mined-out areas in all the workings strike about N. 20° W. and dip about 45° to 55° NE. Most contacts between the ore and wallrock are sheared, but some scattered patches of disseminated ore grade into barren dunite. Production figures for the mine from different sources are at considerable variance and range all the way from 94 long tons, the amount officially reported, to 800 long tons. The official figure includes only production for 1916, but the mine was in operation through 1917 and 1918. The extent of the workings indicates that the lower figure is too small; the more probable figure may be in the neighborhood of 400 long tons. About 3 tons of disseminated ore remain on the dump and perhaps 1 ton of shipping ore remains in sight in the workings.

Kremmel and Froelich Mines (32).—The Kremmel and Froelich mines are on land owned by Carl Froelich in the NW¼NE¼ sec. 3, T. 5 N., R. 10 E., and in the SW¼SE¼ sec. 34, T. 6 N., R. 10 E., on the same ridge as the Carr and Mefford mine. The mine in section 3 is west of the crest of the ridge and was not visited by members of the Geological Survey; the mine in section 34 lies just below the Carr and Mefford workings on the east slope of the ridge near the east contact of the serpentine. In 1916 the properties were leased and operated by Bauers, Case, and Swanson, and later by C. A. Gillis. According to Taliaferro the workings in section 3 consisted of an inclined shaft 25 feet deep pitching northeast at 55°. From this shaft was mined a lens of ore 2 feet thick, striking northwesterly and dipping northeasterly at a moderate angle. The ore shipped from this deposit contained about 33 percent of chromic oxide.

The workings in section 34 consist of a small open-cut from the face of which a tunnel runs into the hill. These underground workings are caved, but in places the ore was stoped to the surface. Small stringers of disseminated and massive ore were seen in some of the workings and these and stoped-out areas strike N. 20° W. and dip about 45° NE. Apparently the shipping ore occurred as irregular clots and bunches in the larger bodies of disseminated ore. Some of the stopes indicate the ore bodies had a maximum thickness of 3 feet. Contact of the ore and the sheared serpentine are generally sharp and slickensided. The property has a recorded production of 357 long tons, all of it listed as having been produced in 1916, but the extent of the workings indicates this figure is excessive, and some of the ore shipped probably came from other sources. Reserves of shipping ore are negligible, and but a few tons of low-grade disseminated ore remain in sight.

Courtwright Property (33) (Woods and Roach Lease).—The Woods and Roach lease is in the NE¼SW¼ sec. 34, T. 6 N., R. 10 E., just west of a saddle on the same ridge as the Carr and Mefford mine. Members of the Geological Survey have not visited the property and the following description is quoted from Taliaferro's unpublished report:

> "The development work consists of two irregular shafts 30 and 32 feet deep, and several trenches. The shafts are 20 feet apart.
>
> "The ore occurs in rather small lenses in a schistose serpentine. The serpentine is rather hard and dense but is much sheared and slickensided. The strike of the lenses of ore and the shearing in the serpentine varies from north and south or northwest-southeast. In the more easterly shaft the strike is N. 50°-55° W., while in the more westerly it is N. 15°-20° W. The variations in strike seem to be local, the general trend being N. 15° W. The dip is high to the east. The ore is separated from the serpentine by slips and can be mined fairly free from waste. There are about 5 or 6 tons of ore in sight unmined and 8 tons of 38 percent ore on the ore pile. The past production has been 80 tons of 38 to 40 percent ore.
>
> "This deposit is about 200 to 225 feet east of the western contact of the serpentine with a series of manganese bearing cherts and metamorphosed tuffs and shales.
>
> "Three hundred yards S. 12° E. of the shafts is a small pit 6 feet deep from which about ½ ton of ore has been taken. There is a small amount of low

> grade ore similar to that seen at the Mooney claim in sight. Between this and the main workings there are occasional small lenses of ore, the largest of which would not contain more than 50 pounds of ore."

Allen Property (34) (Johnson Lease).—The Allen mine is about half a mile north of the Ione-Jackson highway very near the line between secs. 27 and 28, T. 6 N., R. 10 E. C. B. Johnson leased the property from Ed. Allen during the first World War and mined about 20 tons of ore. The following description is taken from Taliaferro's unpublished report:

> "The development work consists of two shafts, 12 and 30 feet deep, and a shallow cut. The shafts are only 10 feet apart. A lens of ore 18 to 20 inches wide is exposed in the bottom of the 12-foot shaft. This lens is rather short and stumpy and is not parallel to the general trend of the schistosity of the serpentine which is N. 30° W. A small amount of low grade ore is exposed in the bottom of the 20-foot shaft and in the trench 50 feet southeast. This low grade ore does not appear to be continuous between the two places. The serpentine is rather hard and compact and frequently shows a felt like structure. This deposit is less than 100 feet east of the western contact of the serpentine with metamorphosed red cherts and tuffs."

The deposit has a recorded production of 63 long tons of chromite, and is said to be worked out.

Plymouth Area

The Plymouth area includes the deposits along a 4-mile portion of a serpentine mass 14 miles long that extends northward into El Dorado County. At its nearest approach the serpentine is 3 miles west of Plymouth. The serpentine mass appears to be a folded sill and the exposed portion is on the east flank of a syncline. Chromite deposits are scattered haphazardly through the serpentine. The district is an area of low, rolling hills having a relief of about 200 feet. None of the mines are now directly accessible by road.

Wait Property (35).—The Wait mine is in the NW¼ sec. 29, T. 7 N., R. 10 E., on land owned by A. L. Wait. The mine was not visited by members of the Geological Survey and the following description is summarized from data contained in Taliaferro's and Logan's reports.

Several small pods and lenses were mined from a number of opencuts, the largest of which was 20 feet deep and 60 feet long. The lenses are parallel to the schistosity of the serpentine and trend N. 20° to 28° W. Lenses range from a few inches to 3 feet in thickness, and from less than a foot to 10 feet in length, and not uncommonly are en echelon. Apparently there was no well-defined zone of ore bodies, although several lenses may occur along the same line.

Most of the serpentine country rock is highly sheared, but occasional patches contain residual pyroxene crystals altered to bastite. A number of light-colored, very dense, fine-grained dikes have been injected into the serpentine, commonly parallel to the schistosity. Chromite float has been found at intervals southward from the mine for nearly a mile. About 71 long tons of ore containing about 38 percent of chromic oxide and 6 or 7 percent of silica has been produced from the mine; nearly all of it was mined and shipping in 1916.

Detert Property (37).—Considerable chromite float and a number of chromite lenses were mined during the first World War from the Detert Ranch near the center of sec. 6, T. 7 N., R. 10 E. The workings, all shallow, are in a gentle swale near the crest of a low hill. Much of the ore was plowed from the soil overlying the serpentine, and a number of lenses were worked from a series of small trenches and pits along a line trending N. 30° W. for a distance of more than 400 feet. Exposures are very poor, and the lenses appear to be small. Those that can be seen strike about N. 30° W. and dip about 55° NE. The ore consists of coarse-grained disseminated and massive chromite. The matrix of the ore is serpentinized dunite, but the shells of dunite surrounding the ore bodies appear to be very small. Most of the country rock is sheared, schistose, serpentinized saxonite. Although contacts of the massive ore are sheared, commonly the contacts between the lenses of disseminated ore and wallrock, though sharp, are but little sheared. Although there is no official record of shipments from this mine, Taliaferro says that about 190 tons of ore containing about 38 percent of chromic oxide was mined from this area. It seems likely that additional ore could be obtained by deeper mining.

Taliaferro described another zone of lenses about a quarter of a mile northeast of the deposit just described, but this could not be located by the present author, for the small cuts Taliaferro described have washed full of soil. The ore was said to have occurred as a series of small irregular lenses extending for a distance of 350 feet along a line trending N. 10° E., but the ore was of lower grade than the ore to the southwest. About 40 tons of ore was produced from this group of deposits.

Taylor Ranch (38).—A deposit of chromite was mined by Pete Hoff during the first World War from land then owned by Koontz in the NE¼ sec. 6, T. 7 N., R. 10 E. The Koontz property was later bought by H. B. Taylor. About 40 tons of coarse-grained massive ore was mined from four shallow pits scattered along a line about 100 feet long. The lenses of ore were quite irregular, had a general trend of N. 15° W. and dipped very steeply eastward. Small amounts of sheared serpentinized dunite are recognizable in the immediate vicinity of the ore bodies, but most of the surrounding country rock is highly sheared serpentine of uncertain derivation. Contacts of the ore and wallrock are sheared and slickensided. Only a few small lumps of chromite are visible and reserves are negligible.

Other Deposits.—From the Dooley property (36), a short distance north of the Wait mine, about 10 tons of ore containing 38 percent of chromic oxide was shipped during the first World War. Some ore is said to have been produced from a prospect about three-quarters of a mile southeast of the Detert mine, and a small lens is said to crop out on the Joe Garibaldi Ranch in the SE¼ sec. 31, T. 8 N., R. 10 E.

East Group

The east group of chromite deposits is in a more rugged, difficultly accessible region than the west group, and this condition combined in all probability with an actually smaller number of deposits accounts for the small number of discoveries. The group contains but two areas, the Murphy, and the Railroad Flat.

Murphy Area

The Murphy area is about 5½ miles north-northeast of Angels Camp and about 2½ miles west of Murphy. Low mountains having steep, rather smooth slopes and a relief of 1,500 feet characterize the area. Two or three small, lenticular serpentine masses crop out in the district, but from only one of them has any chromite been reported.

Madrid Mine (True Blue) (39).—The Madrid mine is about half a mile south of San Domingo Creek at an elevation of about 2,000 feet in the SW¼ sec. 2, T. 3 N., R. 13 E. In 1945, the property was owned by Adolph

Genochio, but during the first World War the property was owned and operated by John Madrid. The mine is reached from San Andreas over 11 miles of surfaced highway and 3 miles of graded dirt road.

Workings consist of an open-pit 45 feet long, 45 feet wide, and 15 feet deep, and an inclined shaft in the floor of the pit cleaned out to a depth of 25 feet.

The ore body is an irregular, broken lens of nearly massive and medium-grade disseminated chromite striking N. 80° W. and dipping 65° SW. The lens has a maximum thickness of 12 feet, but the length is unknown. The country rock is a schistose, altered serpentine. Contacts of the ore and serpentine are sheared and slickensided. Numerous small dikes altered largely to chlorite cut the ore and the surrounding serpentine; these dikes are probably related to the remarkably large crystals of green chrome mica or chlorite found in the open fissures. Some of the ore is nearly pure chromite, but most of it contains considerable quantities of dark-colored serpentine indistinguishable on superficial examination from the chromite.

The mine has a recorded production of 1,039 long tons of chromite containing about 30 percent of chromic oxide. Practically all the ore above the level cleaned out in 1942 has been mined, but considerable ore is said to remain in the bottom of the workings. Nearly all the ore credited to the east group of deposits has come from this one mine.

Valenti Claim (40).—The Valenti claim is a few hundred feet below the Madrid mine in the SW$\frac{1}{4}$ sec. 2, T. 3 N., R. 13 E. on land owned by Charles Valenti. This claim is one of the two or three new deposits discovered in Calaveras County since the first World War. Aside from a minor amount of trenching the deposit has not been worked.

The deposit consists of a lens of nearly massive chromite, 1 to 4 feet thick, striking N. 60° E. Trenching has exposed the lens through a vertical distance of 25 feet and a horizontal distance of 60 feet. The country rock is sheared serpentine, and contacts of the chromite and serpentine are sheared and slickensided. The ore is medium-grained, nearly massive chromite and contains only minor amounts of interstitial serpentine, but according to assays received by Mr. Valenti the chromic oxide is low, being but 28 percent. Perhaps 200 tons of ore could be mined from the deposit.

Railroad Flat Area

The Railroad Flat area lies about 2½ miles south of Railroad Flat. The area has a relief of several hundred feet, although slopes are rather gentle and smooth. Small lenses of serpentine crop out in the area, and as very little chromite has been mined in the district it was not investigated by members of the Geological Survey.

Late Property (41).—The following description is summarized from Taliaferro's report.

The property lies on the rather broad divide between the North Fork of Calaveras River and Esperanza Creek at an elevation of about 2,800 feet in sec. 3(?), T. 5 N., R. 13 E. The property was owned by Mrs. D. Late and operated by Frank Pickard during the first World War. So far as is known the property has been idle since 1918.

At the time of Taliaferro's visit about 45 tons of chromite float had been dug from soil 18 to 40 inches deep overlying highly talcose, schistose serpentine, but no ore had been found in place. Workings covered an area of several thousand square feet. Pieces of chromite ranged in size from small fragments to blocks 8 inches in diameter, and averaged about 3 inches in diameter. The ore was high grade and one assay gave a chromic oxide content of 49.6 percent.

Burns and O'Neill Property (42).—The following description is based on Taliaferro's unpublished report.

The mine is 1½ miles by road south-southwest of the Late property on the north side of Esperanza Creek in sec. 9, T. 5 N., R. 13 E. During the first World War the property was owned and operated by Charles Owens and C. O'Neill, but so far as is known the mine has been idle since 1918. Workings consisted of a pit 12 feet deep and several shallow trenches. Though about half a ton of high-grade chromite float was found, the only ore in place was very low grade and consisted of very small grains of chromite irregularly scattered through very talcose serpentine. This ore occurred in small irregular streaks as much as 4 or 5 inches wide in the bottom of the pit. There is no record of any ore having been shipped from the property.

Other Deposits.—Only one deposit has been reported from the east belt of serpentine in Amador County. Taliaferro was told that a carload of ore was shipped in 1917 from a prospect in T. 8 N., R. 11 E., but was rejected because the chromic oxide content was too low. Nothing further is known concerning the deposit.

ALPHABETICAL LIST OF CHROMITE MINES AND PROSPECTS

In the accompanying table the chromite mines and prospects are listed alphabetically. Ownership is given as of the date of the last report on the property, and for some mines the owner is unknown. The deposits are divided by production into four classes: A, deposits or properties that have shipped at least 1,000 long tons; B, deposits that have shipped between 150 and 1,000 long tons of ore; C, deposits from which some ore but less than 150 long tons have been shipped; and D, deposits from which no ore has been shipped.

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Alphabetical list of chromite mines in Calaveras and Amador Counties, California

Calaveras County

Map no. (pl. 5)	Name	Owner	Location			Class by production	Remarks
			Sec.	T. (N.	R. (E.)		
6	American Asbestos Co.	Unknown	N.W. 16	1	13	C	Worked out
8	Bear Mtn. Ranch	Unknown	N.W. 32	1	12	D	
1	Bowie Estate	Bowie Estate	9, 16	1	13	B	
	Bushy Hill: See Walker						
11	Burnham	Beecham	N.W. 23	2	12	C	
	Burnham & Wilson: See Mayflower						
42	Burns & O'Neill	Unknown	9	5	13	D	
	Chaparral: See Walker						
14	Clary & Langford		N.W. 10	2	12	B	Worked out
	Coffer, Trask & Stone: See Stone						
10	Davis	Beecham	S.E. 23	2	12	B	
4	Dean	Unknown	N.W. 9	1	13	C	
19	Ellingwood	City of Stockton	N.W. 21	4	11	B	Some ore remains
18	Ellingwood & Vogelsang	Wm. Ellingwood	S.E. 28	4	11	B	Production probably over 200 tons
26	Field & Stoker	City of Oakland	S.E. 24	5	10	C	
24	Field & Stoker (Briggs lease)	City of Oakland	23	5	11	C	
	Genochio: See Madrid						
21	Gillam	J. Gillam	S.W. 31	4	11	C	Worked out
20	Granadas	Si Granadas	N.E. 20	4	11	D	
13	Hinch	Hinch	S.W. 3	2	12	B	
5	Holbrook & McGuire	Bowie Estate	8, 9	1	13	B	Some disseminated ore
41	Late	D. Late	3	5	13	C	Float only
2	Liberty	Unknown	N.W. 9	1	13	B	
	Longton: See Stone						
39	Madrid	A. Genochio	S.W. 23	3	13	A	
15	Mathew	Mathew	29	3	13	C	
16	Maxwell	Maxwell	2	4	11	C	
3	Mayflower	Unknown	N.W. 9	1	13	B	
	McFall: see Liberty						
25	McNamara	McNamara	S.W. 32	5 N.	11	C	
23	Neugebauer	Neugebauer and City of Oakland	S.E. 31	5	11	D	15-20 tons of ore on dump
7	Peri	Peri	32	2	13	C	
	Porter & Spring: See Clary & Langford						
9	Stone	Chas. Stone	S.E. 23				
			S.W. 24	2	13	C	
22	Sartorious & McClellan	Ross	N.E. 6	4	11		Disseminated
	True Blue: See Madrid						
40	Valenti	Chas. Valenti	S.W. 2	3	13	D	Perhaps 200 tons of reserves
17	Vogelgesang	G. D. Vogelgesang	S.W. 34	4	11	B	Some ore on dump
12	Walker	B. C. Creswell	15	2	12	C	Probably worked out
27	Ward & Lyons	City of Oakland	S.E. 24	5	10	A	Some ore remains

Alphabetical list of chromite mines in Calaveras and Amador Counties, California—Continued

Amador County

Map no. (pl. 5)	Name	Owner	Location			Class by production	Remarks
			Sec.	T. (N.)	R. (E.)		
34	Allen property (Johnson lease)	Ed. Allen	27, 28	6	10	C	Worked out
31	Carr & Mefford (Mooney lease)	Devem Cenzi	S.E. 34	6	10	B	Some disseminated
30	Courtwright property (Dagget lease)	Lyda Courtwright	S.E. 3	5	10	C	
33	Courtwright property (Wood & Roach lease)	Lyda Courtwright	S.W. 34	6	10	C	
37	Detert property	Detert	6	7	10	B	Mostly float
36	Dooley					C	North of Wait property
29	Ellis property	J. M. Ellis	E. ½ 2	5	10	D	10 tons of ore on dump
28	Fields mine	City of Oakland	S.W. 10	5	10	C	1 ton of ore on dump
	Garibaldi property	Joe Garibaldi	S.E. 31	8	10	D	Outcrops of chromite
32	Kremmel & Froelich mine	Carl Froelich	S.E. 34	6	10		
			N.E. 3	5	10	B	Some disseminated
38	Taylor ranch	H. B. Taylor	N.E. 6	7	10	C	
35	Wait property	A. L. Wait	N.W. 29	7	10	C	

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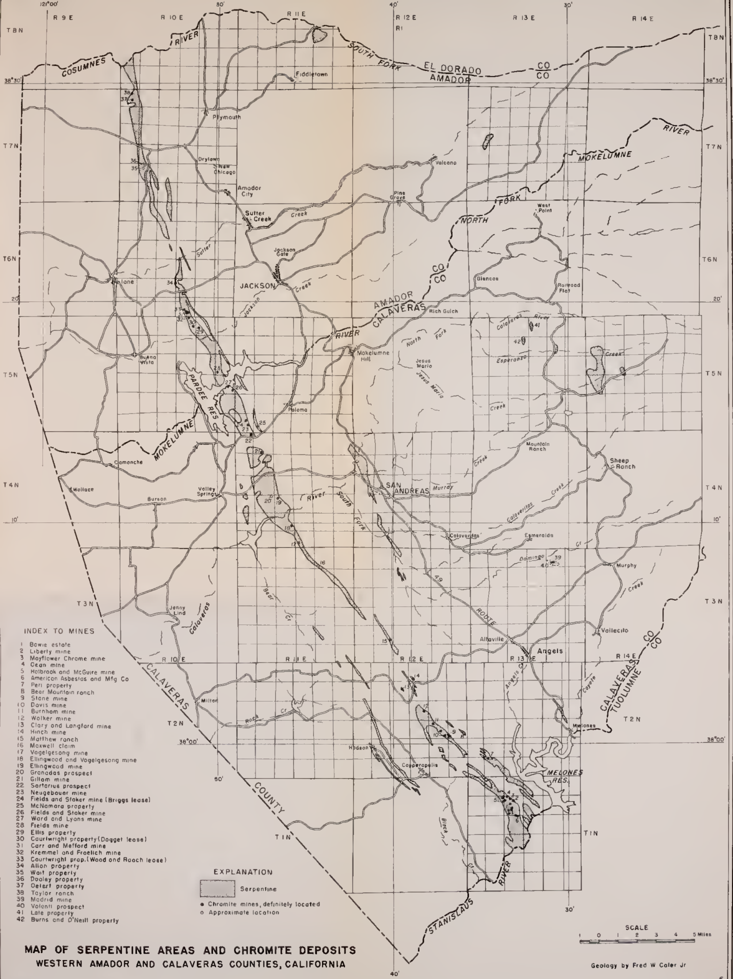

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11 Burnham mine
12 Walker mine
13 Clary and Langford mine
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15 Matthew ranch
16 Maxwell claim
17 Vogelgesong mine
18 Ellingwood and Vogelgesong mine
19 Ellingwood mine
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21 Gillam mine
22 Sartorius prospect
23 Neugebauer mine
24 Fields and Stoker mine (Briggs lease)
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26 Fields and Stoker mine
27 Ward and Lyons mine
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38 Taylor ranch
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40 Valenti prospect
41 Late property
42 Burns and O'Neill property

EXPLANATION

▨ Serpentine

● Chromite mines, definitely located

○ Approximate location

SCALE

1 0 1 2 3 4 5 Miles

MAP OF SERPENTINE AREAS AND CHROMITE DEPOSITS
WESTERN AMADOR AND CALAVERAS COUNTIES, CALIFORNIA

Geology by Fred W Cater Jr

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